

## CLAIMS

We claim:

1. A catalyst comprising:  
5 a porous substrate having an average pore size of from 1  $\mu\text{m}$  to 1000  $\mu\text{m}$ ; and  
disposed over the porous substrate, a zirconia-supported, alkali-metal-modified,  
ruthenium catalyst.
2. The catalyst of claim 1 made by steps comprising: impregnating zirconia with  
10 solution containing Ru and K, calcining, and reducing.
3. The catalyst of claim 1 comprising 0.1 to 10wt% Ru and 0.1 to 10wt% K.
4. The catalyst of claim 1 comprising a large pore support wherein at least 20% of  
15 the catalyst's pore volume is composed of pores in the diameter size range of 0.1 to 300  
microns.
5. The catalyst of claim 4 characterized by a test in which the catalyst is tested by  
placement in a reaction chamber and contacted with a reactant gas mixture containing 8%  
20 CO, 7% CO<sub>2</sub>, 38% H<sub>2</sub>, and 47% H<sub>2</sub>O, at a contact time of 50 ms and a temperature of 325  
°C, it results in greater than 70% CO conversion and at least 80% CO<sub>2</sub> selectivity.
6. The catalyst of claim 1 characterized by a test in which the catalyst is tested by  
placement in a reaction chamber and contacted with a reactant gas mixture containing 8%  
25 CO, 7% CO<sub>2</sub>, 38% H<sub>2</sub>, and 47% H<sub>2</sub>O, at a contact time of 25 ms and a temperature of 420  
°C, it results in greater than 70% CO conversion and at least 80% CO<sub>2</sub> selectivity.
7. A method of producing hydrogen gas comprising:  
flowing a reactant gas mixture into contact with a catalyst;  
30 wherein the reactant gas mixture comprises carbon monoxide and water vapor;

wherein the catalyst comprises a zirconia-supported, alkali-metal-modified, ruthenium catalyst; and  
forming hydrogen gas.

5     8.     The method of claim 7 wherein the reactant gas mixture comprises 3 to 20% CO, 3 to 60% H<sub>2</sub>O, 3 to 20% CO<sub>2</sub>, and 10 to 60% H<sub>2</sub>.

9.     The method of claim 8 wherein the catalyst is at a temperature of 200°C to 420°C.

10

10.    The method of claim 7 wherein the catalyst comprises a large pore support and the catalyst is at a temperature of 250°C to 350°C.

11.    The method of claim 9 wherein said step of flowing is controlled so that the  
15    contact time is in the range of 3 to 100 milliseconds.

12.    The method of claim 7 where the selectivity to carbon dioxide is at least 70% and the conversion of CO is at least 70%.

20    13.    A reactor comprising:  
a reactor inlet, a reaction chamber, a reactor outlet, and a microchannel heat exchanger;

wherein the reaction chamber contains a zirconia-supported, alkali-metal-modified, ruthenium catalyst; and

25       wherein the microchannel heat exchanger is in thermal contact with the reaction chamber.

14.    The reactor of claim 13 wherein the reaction chamber has a width less than 2 mm.

15. The reactor of claim 14 wherein the heat exchanger is adjacent to the reaction chamber and wherein the heat exchanger has a width of less than 2 mm.

16. The reactor of claim 15 comprising at least two heat exchangers that are  
5 interleaved with at least 2 reaction chambers.

17. A fuel processing system comprising the reactor of claim 13.

18. A hydrogen production system comprising:  
10 a fuel tank;  
a primary conversion reactor capable of converting fuel to produce carbon monoxide;  
wherein the primary conversion reactor comprises a fuel inlet, a primary conversion reactor chamber and an exhaust outlet;  
15 a water gas shift reactor comprising a shift reactor inlet, a reaction chamber, and a shift reactor outlet;  
wherein the shift reactor inlet is connected to the combustor exhaust outlet; and  
wherein the reaction chamber contains a zirconia-supported, alkali-metal-modified, ruthenium catalyst.

20

19. The hydrogen production system of claim 18 further comprising a fuel cell to form a fuel processing system.

20. The hydrogen production system of claim 18 further comprising a secondary CO  
25 clean up system.

21. The hydrogen production system of claim 20 further comprising a fuel cell to form a fuel processing system.

30